Human Factors Techniques for the Design of the Virtual Mission Operations Center

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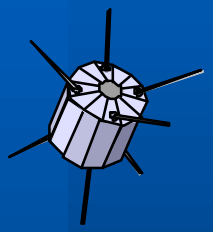
Agenda

- **NASA Mission Operations**
- **The VMOC Concept**
- **Human Factors Techniques**
- **Project Status**

Mission Operations



Spacecraft:

Payloads & Subsystem

Users:

Scientific Needs

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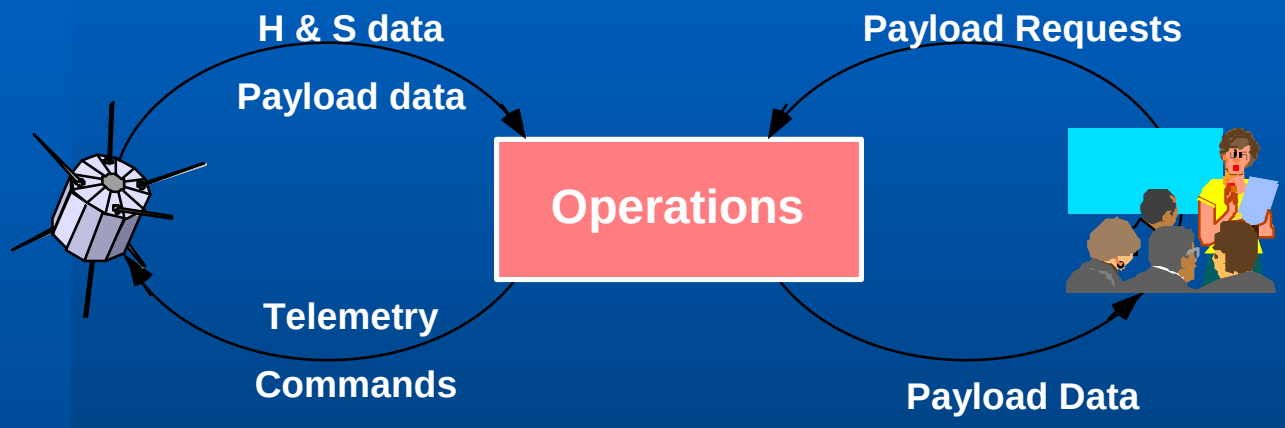
Mission Operations



Spacecraft:

Payloads & Subsystem

Operations Center:

Humans w/

Computer Support

Users:

Scientific Needs

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Flight Operations Team (FOT)

- **Command Controller**
- **Spacecraft Analysts and Engineers**
- **Flight Supervisor**
- **Support Staff As Needed**

FOT Activities

- **Mission Planning and Scheduling**
- **Command Management**
- **Test and Simulation**
- **Institutional Interface Support**
- **Operations (Real Time Passes)**
  - **Commanding Spacecraft**
  - **Fault Management**

Operations Environment

- **Current Environment**
  - **7 x 24 Support**
  - **Unique and Dedicated Resources**
- **“Lights Out” Environment**
  - **(5x8) or 1 shift/day**
  - **On-call FOT**
  - **Multi-mission support**

Consequences

- **Support distributed teams**
- **Cost effective, yet**
  - **functional**
  - **reliable**
  - **secure**
- **Easy to use**
- **Flexible**

Response -- VMOC

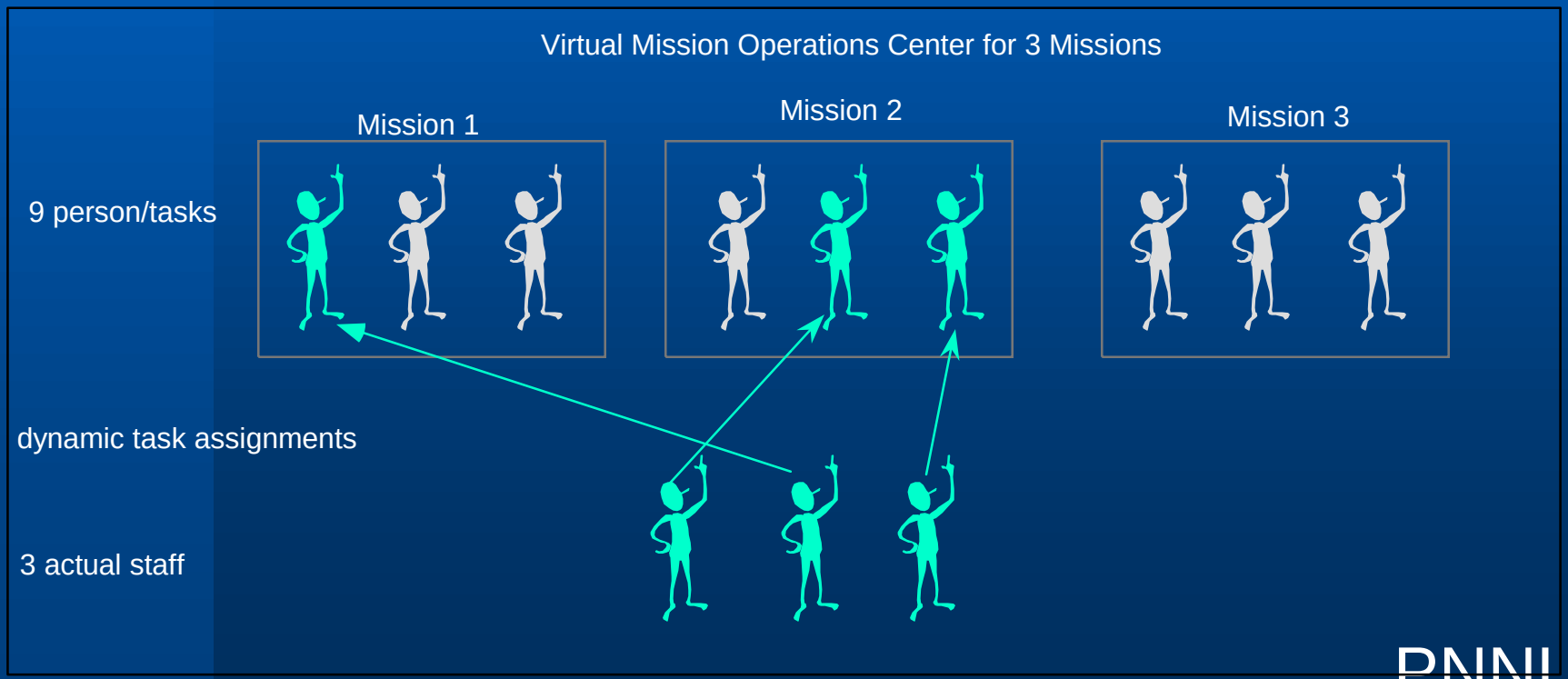
Virtual Mission Operations Center

- **Goal: To work with mission operations staff to develop the future technology and workgroup computing concepts that will be needed to meet the new ground rules for mission operations.**

- **Objectives: Demonstrate, evaluate, and integrate advanced technologies which**
  - **Increase operator efficiency**
  - **Minimize use of dedicated resources**

Concept of Virtual Operations

- **People and resources are mapped according to skills, experience, and availability to meet the needs of a multiple mission, distributed, operations facility. They can be distributed, and may join in ad hoc groups to meet the occasional peak demands.**



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Human Factors in VMOC Design

- **Concept Definition**
- **Proof of Concept**
- **Development**

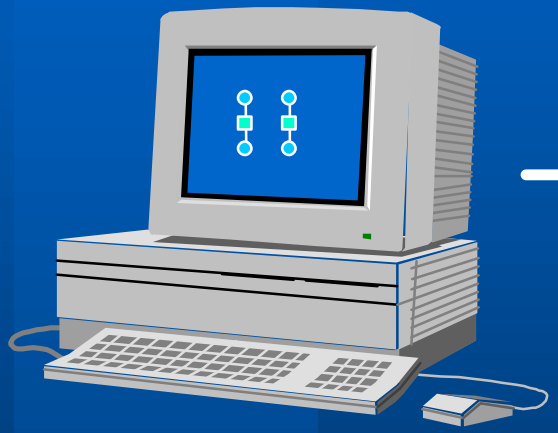
Concept Definition (Phase I)

- **Predefined Plan**
  - **Real-time Fault management**
  - **Heavy use of advanced AI tools**
  - **Support for group work**
- **Needs Assessment**
  - **Interviews**
  - **Literature review**

Concept Definition (Phase I)

- **Conceptual Prototyping**
  - **Implement basic VMOC concepts,**
  - **Demonstrate each prototype to users**
  - **Produce a prototype that can be used as a foundation for further development**
- **Environment**
  - **G2 expert system**
  - **Custom software**

G2/IMT Development Environment



IMT
Satellite control toolkit

G2

Real-time process control expert system

- **SYBASE**
- **DB gateway**
- **Front-end processor gateway**

Unix, X-Windows, TCP/IP

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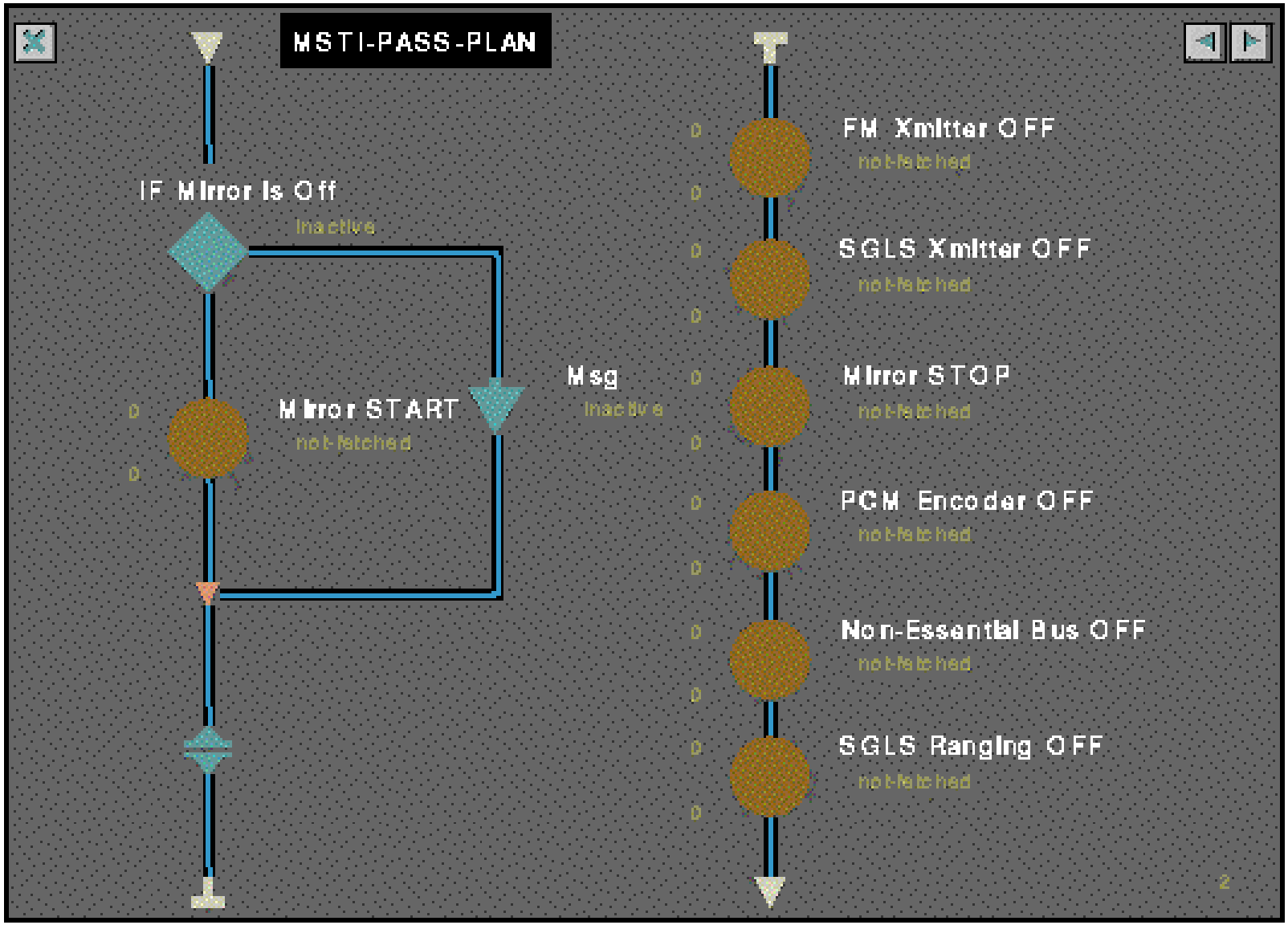
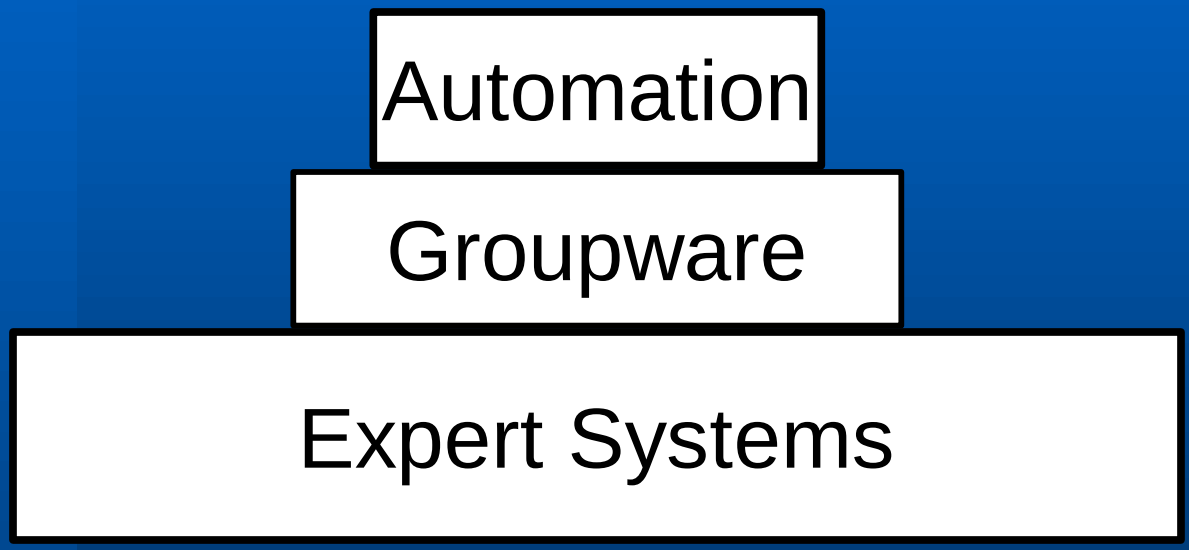
IMT Pass Plan



Concept Definition (Phase I)

- **Results**
  - **Wheel spinning**
  - **Long prototyping cycle**
  - **Not much user support**
- **Why?**
  - **Always done this way**
  - **Typical R&D organization**
  - **Focus on technologies**

Concept Definition (Phase I)



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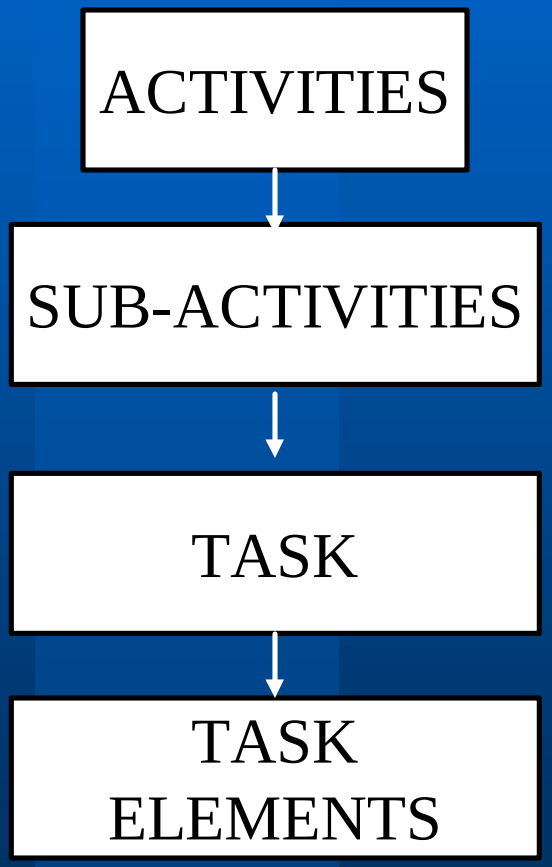
Concept Definition (Phase II)

- **Interviews & Observations**
  - **GRO, EUVE, SAMPEX, Hubble Space Telescope**
- **Composition Graphs**
  - **Flowcharting methodology**
  - **Used to depict operations concepts**

Composition Graphs Elements



A group of subactivities

Operations that are performed in response to a single event

Smallest Discrete unit of work

A single identifiable step in a task

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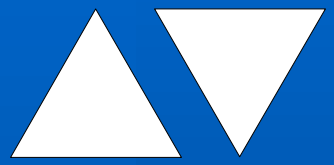
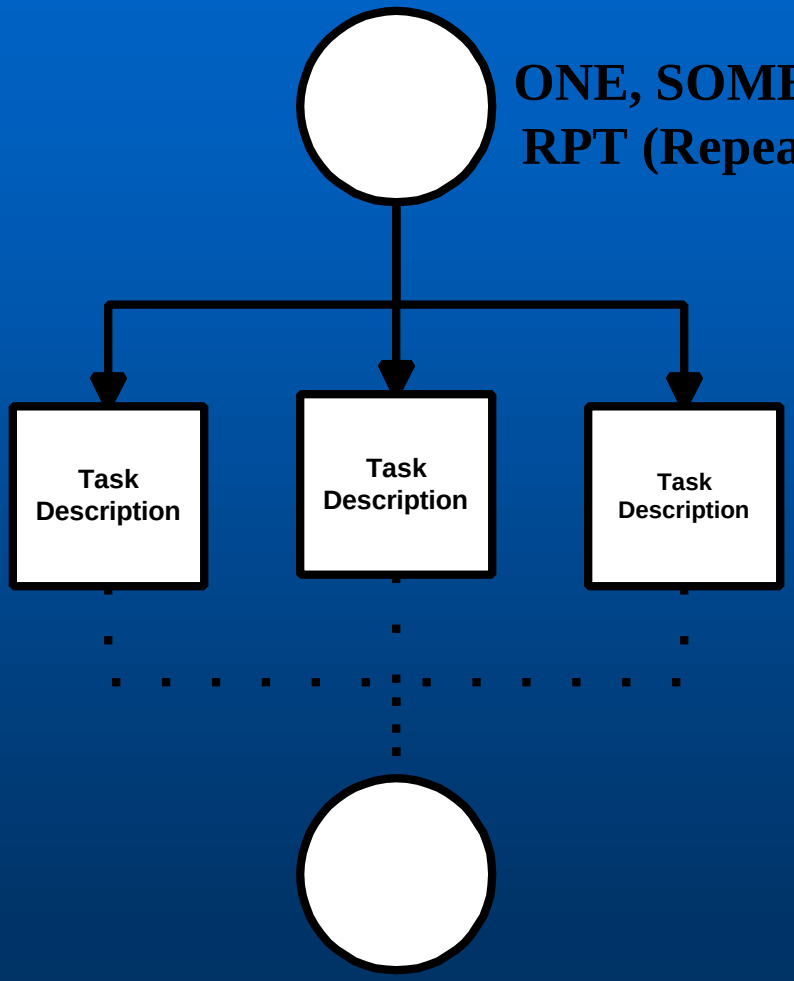
Components



Begin, End

Coordinators
Task Description
Coordination Media

Macro Description



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Concept Definition (Real Needs)

- **Scenario-Based Designed**
  - **Three Scenarios**
    - **Simple (Basic Management by Exception)**
    - **Moderate (Distributed Management by Exception)**
    - **Complex (Dynamic Distributed Management by Exception)**
  - **Descriptions**
    - **Text**
    - **Matrix**

Scenario Matrix

SCENARIO 1

Activities	Tasks	Action by: Autonomous (A) Operator (O) Engineer (E)	Build # 1, 2, 3 Simulated (S) Future build (F)
Off-line activities	Open appropriate pass plan	O	1
	Translate activity requests into pass plan	A	1 (S)
	View and edit graphical pass plan	O	1
	Assign emergency support person	O	1 -- change pass plan 2 -- use team building tool to assign support
	Notify person of assignment	A	3
	Set plan to automatic execute mode	O	1
	Check rules for pass plan commands	A	2
	Save pass plan	O	1

Concept Definition (Real Needs)

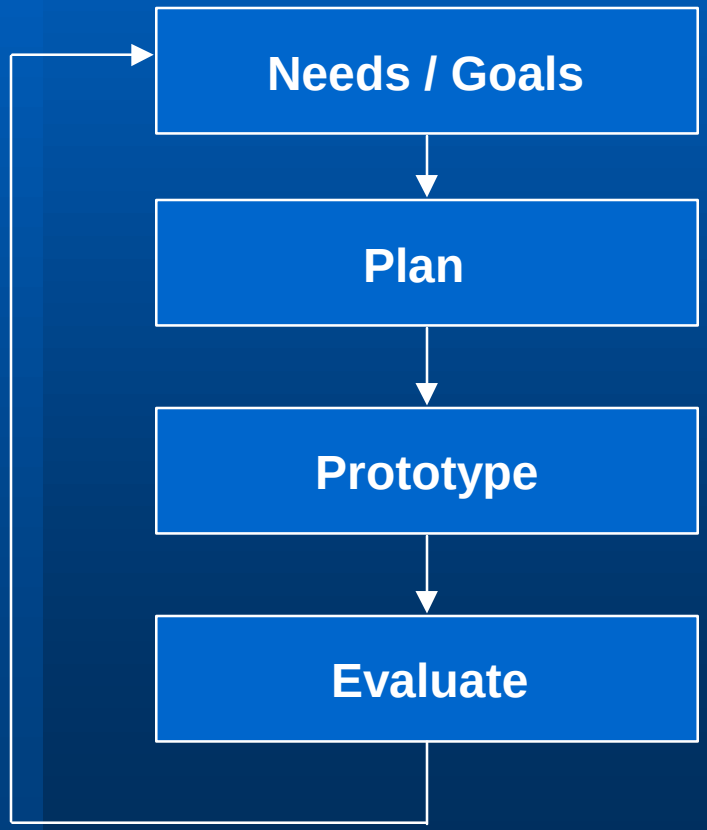
- **Steering Committee**
  - **Members**
    - **Actual Operations Staff**
    - **Volunteers**
  - **Responsibilities**
    - **Provide feedback**
    - **Attend review meetings**

Concept Definition (Results)

- **Findings**
  - **Not many anomalies, but when occur:**
    - **Not much time to respond to anomalies**
    - **Resolution requires team communication**
  - **Lack of flexibility**
  - **Lots of paperwork**
- **Changed Priorities**
  - **Highest payoff is automating routine tasks**
  - **Reducing workload and facilitating cooperative tasks**

Concept Definition (Results)

- **More Formal Approach**
- **User-centered participatory design**



Use a ‘design-build-test-revise’ process

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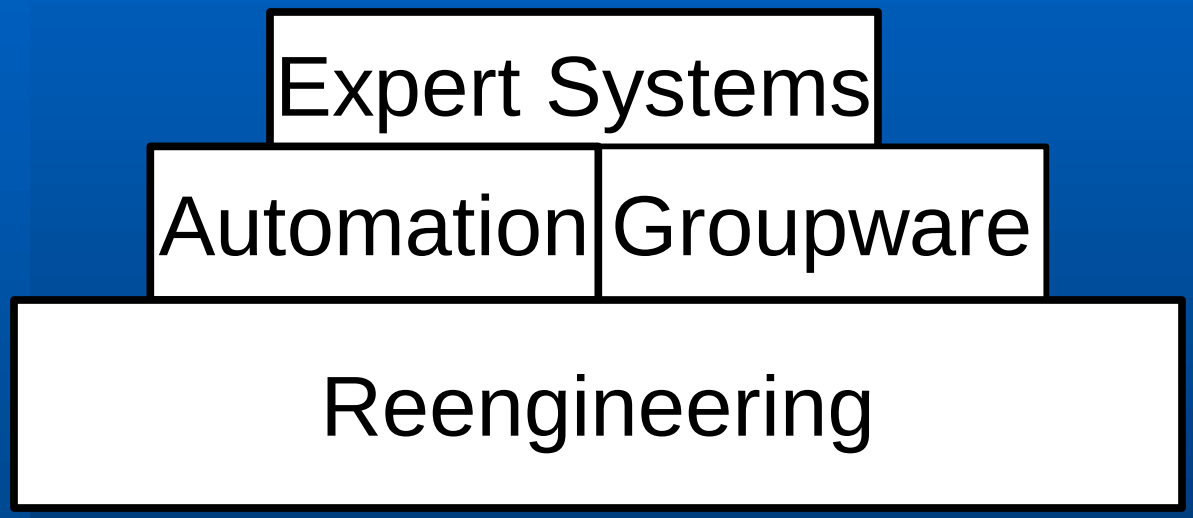
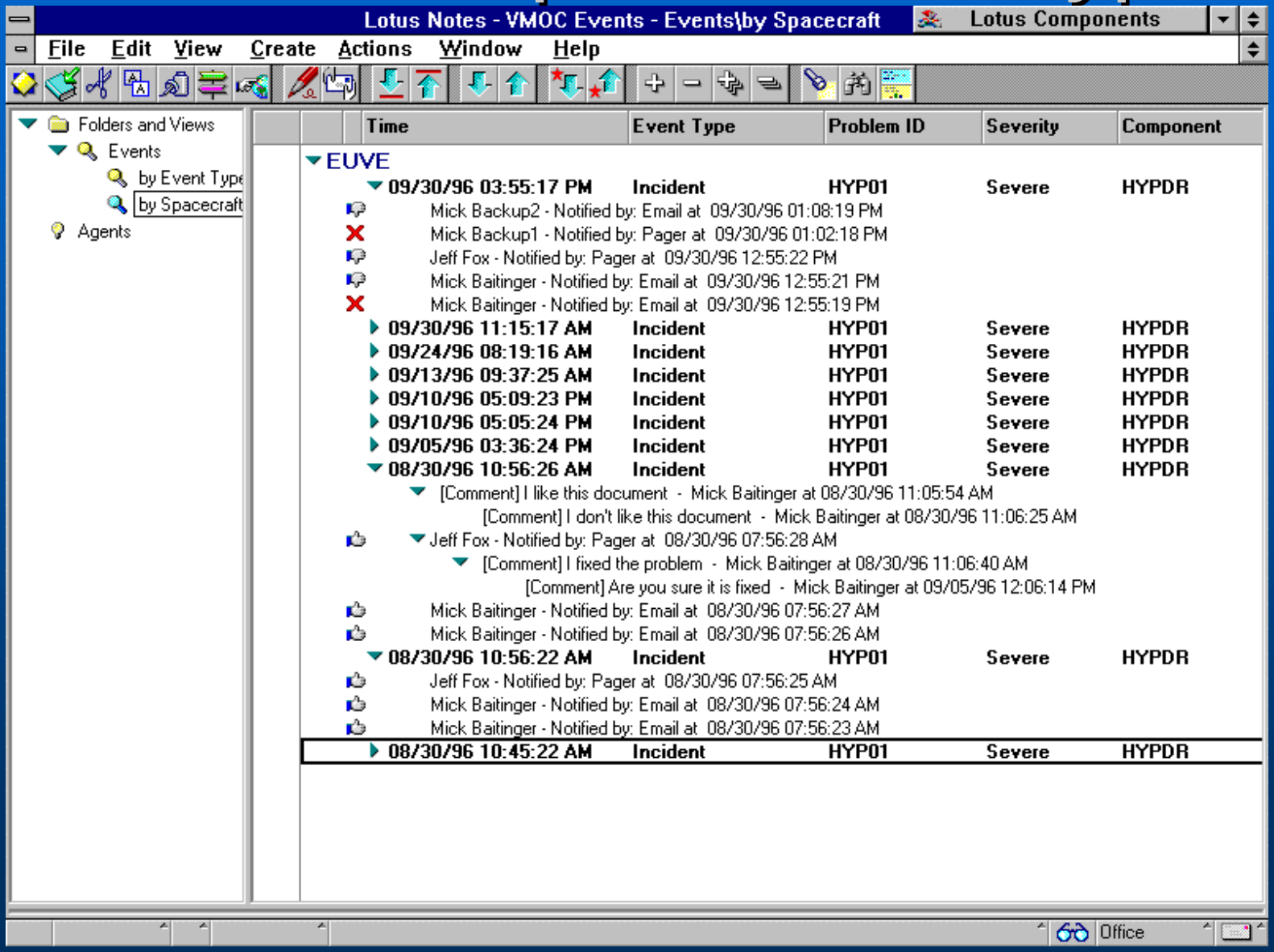
Concept Definition (Results)



Proof of Concept (Method)

- **Needs**
  - **Feedback from previous phase**
  - **Iterations of scenarios**
- **Cooperative Prototyping**
  - **Highly interactive and interactive**
  - **Demonstrate new features**
  - **Demonstrate revised designs**
  - **Collect feedback**

Initial Groupware Prototype



Proof of Concept (Results)

- **User By-In**
- **More realistic Designs**
- **Enthusiasm on Development Team**

Development (Method)

- **Needs**
  - **Feedback from previous phase**
  - **Iterations of scenarios**
- **High-Fidelity Prototyping**
  - **Cooperative**
  - **Ok'ed --> Operational**
  - **Expert review**
  - **User walkthroughs**
- **Trail-by-Fire**

Development (Results)

- **First Success - TRACE I & T**
- **Interest from other missions**

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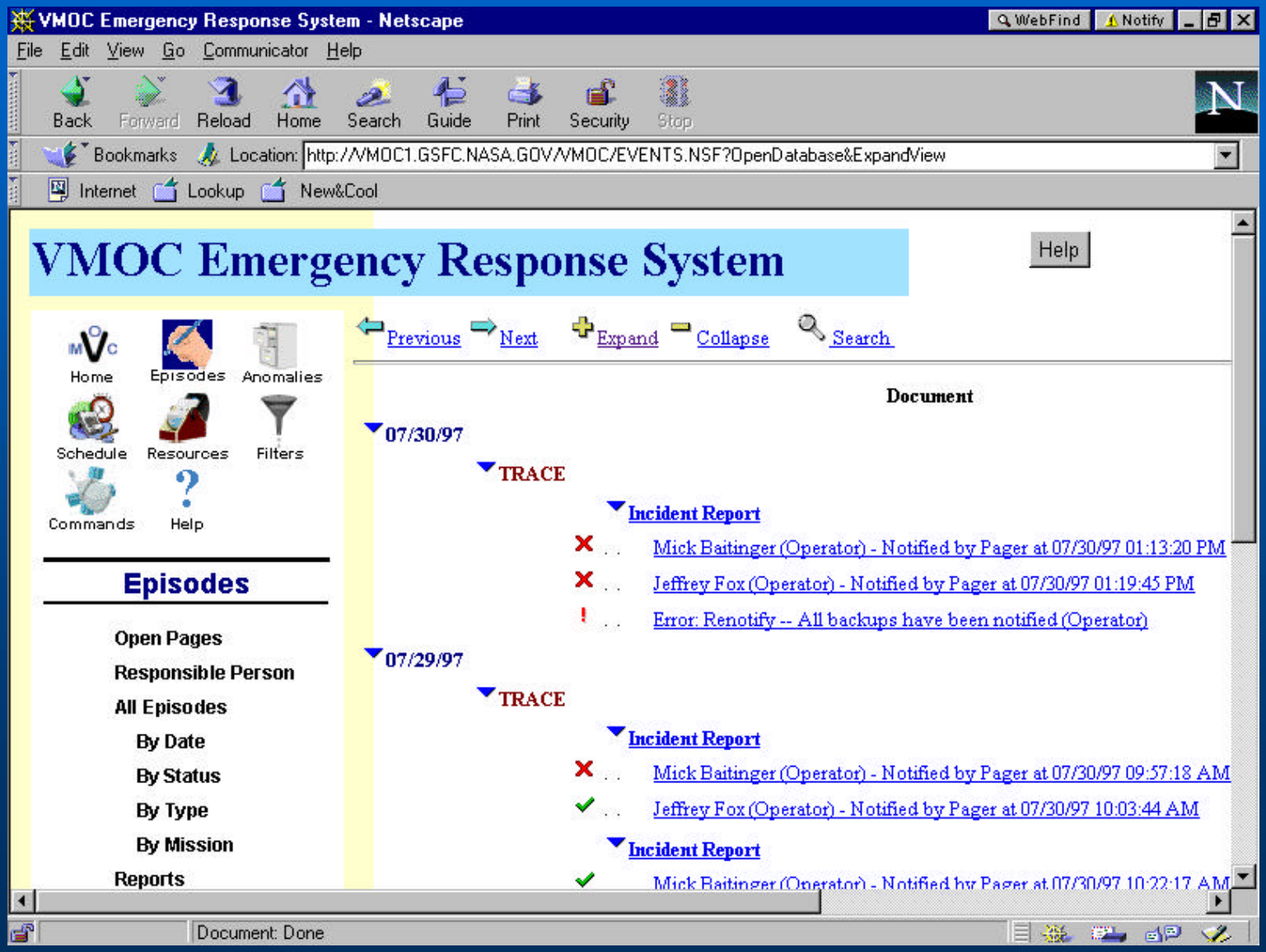
Current Design

- **Groupware-based solution**
- **Web access**
- **Automated logging and report generation**
- **On-line staff scheduling and resource management**
- **On-line documentation**
- **Communications alternatives**

Current Design



Development Status and Plans

- **7/97**
  - **Ground System I&T Anomaly Database Operational**
- **8/97**
  - **Support TRACE Thermal Vac Testing (Shadow Mode)**
- **9/97**
  - **Release 1 (TRACE Critical Path)**
- **3/97**
  - **Operational**

Conclusions

- **Each human factors technique is useful**
- **High impact on program**
  - **improved design**
  - **Refocused project**